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# Jefferson Lab Overview

**Anthony W. Thomas**

**Chief Scientist**

**12 GeV Upgrade Science Review  
Jefferson Lab  
April 6-8, 2005**



Thomas Jefferson National Accelerator Facility



# Jefferson Lab At A Glance

- **World leader in nuclear physics research, devoted to the investigation of the quark-gluon structure of nuclei, nucleons and mesons**
- **An Office of Science user facility - JLab serves more than 2100 users from 30 countries and 33 states**
  - **1/4 of all U.S. Ph.D.s in Nuclear Physics**
- **Unique capabilities and facilities for the exploration of the quark structure of matter**
  - **Strong theoretical analysis and computer simulations in LQCD support/complement the experimental program**
  - **The cw, 6 GeV, polarized beam is made possible by rf superconductivity**
  - **SRF is also the basis for JLab's partnership with the SNS, the 12 GeV Upgrade and the record breaking, energy recovering JLab Free Electron Laser (scientific, industrial, and defense applications)**
- **JLab enjoys exemplary community relations, and enhances science education at all academic levels through its outreach programs**



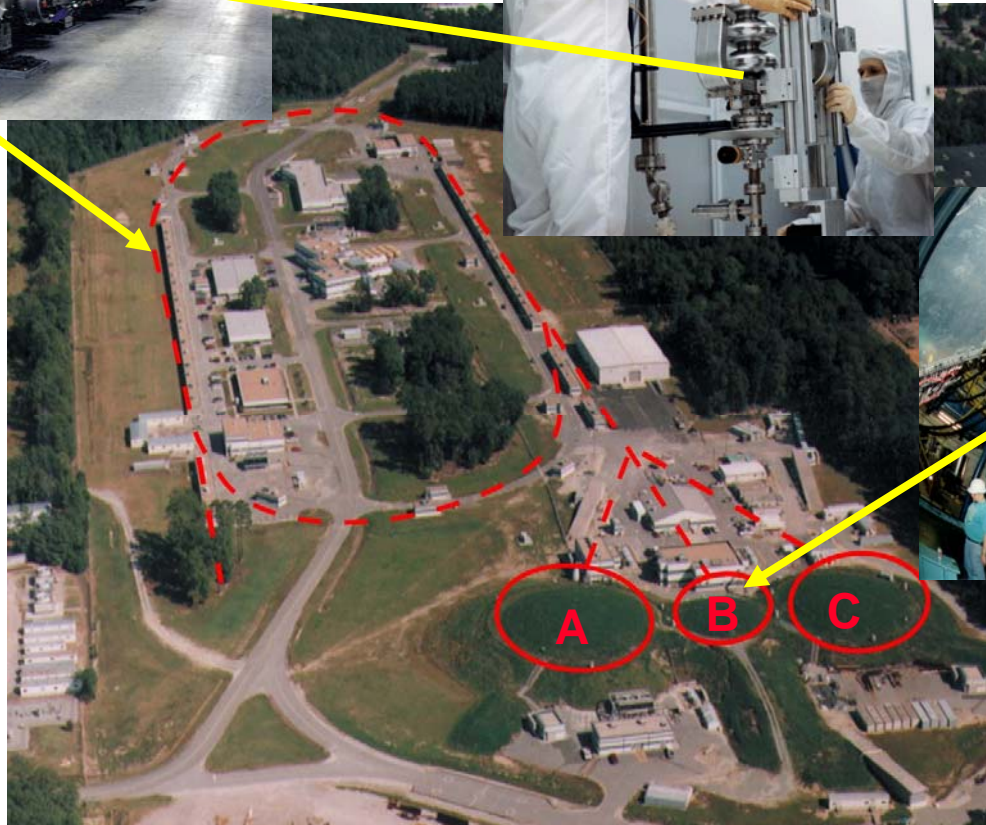
# Unique Forefront Capabilities for Science



Cryomodules in the accelerator tunnel



Superconducting radiofrequency (SRF) cavities undergo vertical testing.



An aerial view of the recirculating linear accelerator and 3 experimental halls.



CEBAF Large Acceptance Spectrometer (CLAS) in Hall B

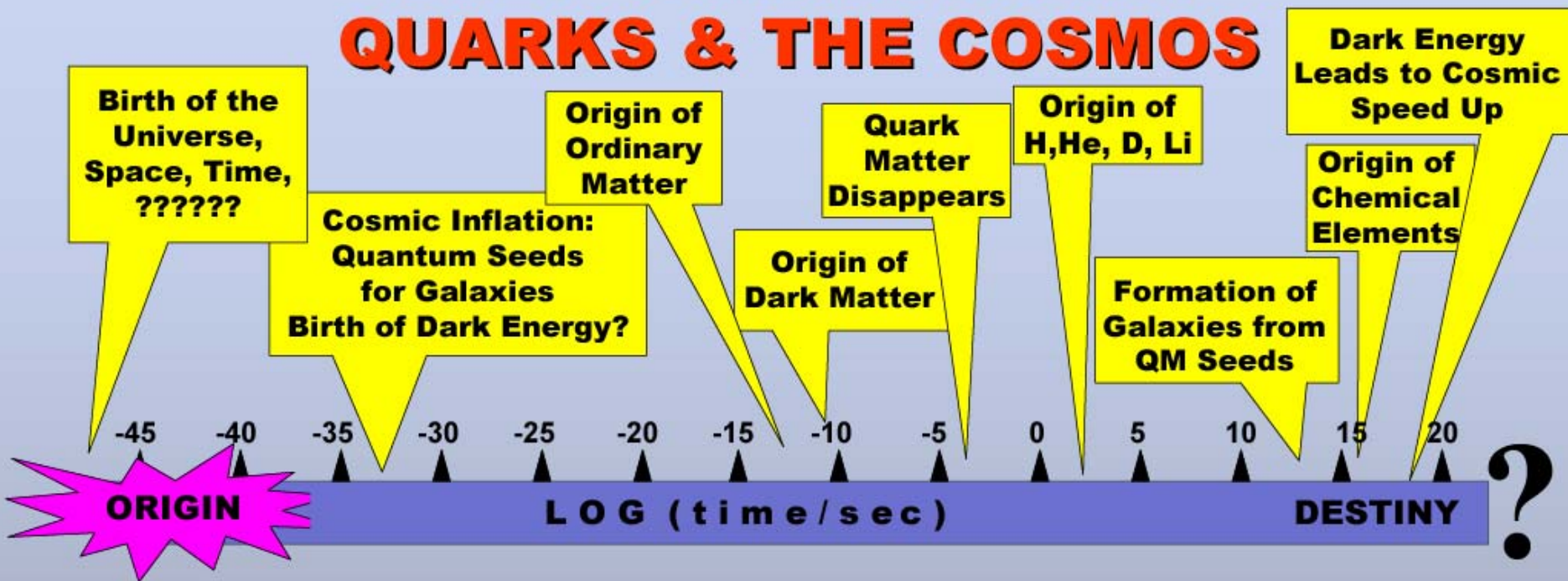


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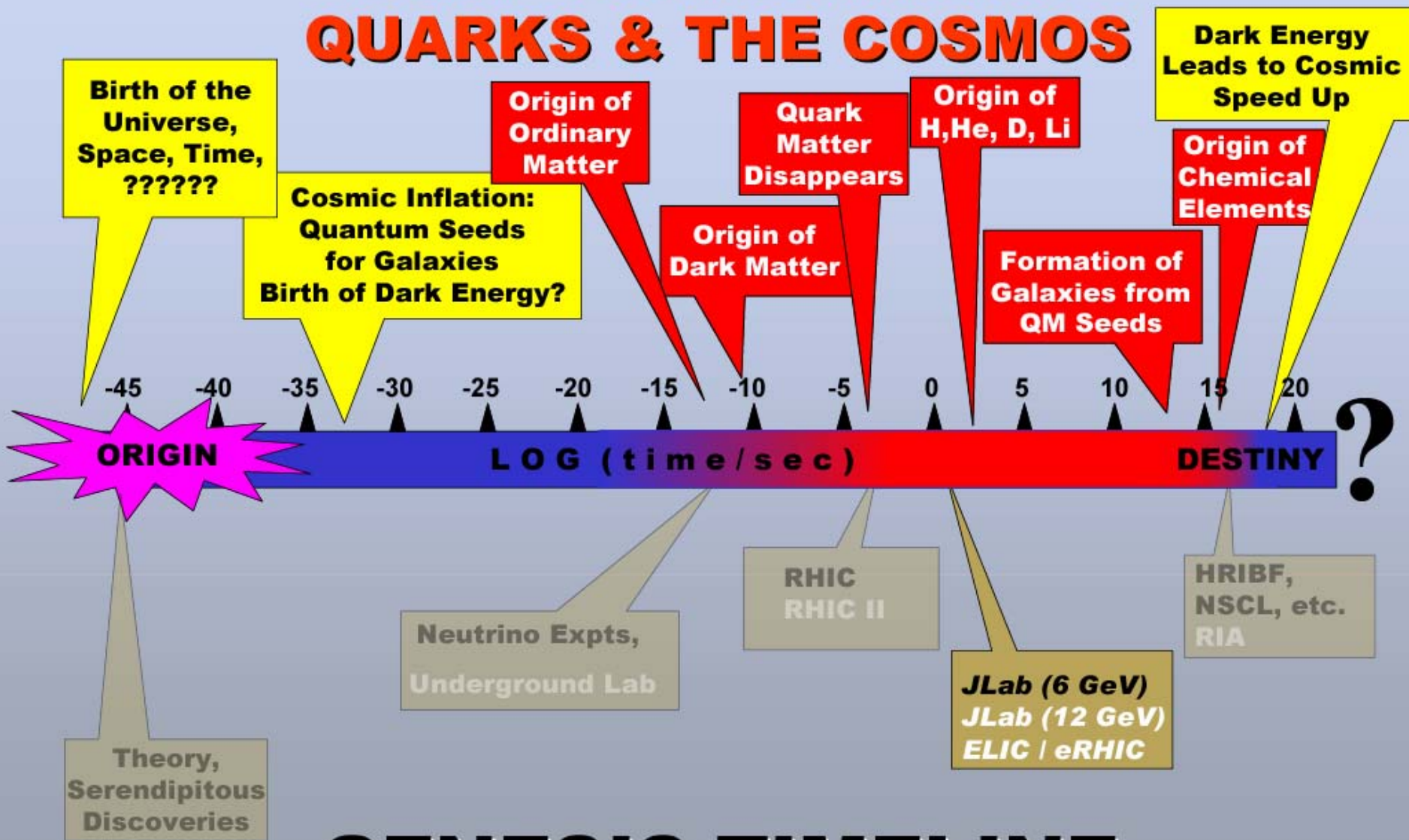


# DEEP CONNECTIONS: QUARKS & THE COSMOS



## GENESIS TIMELINE

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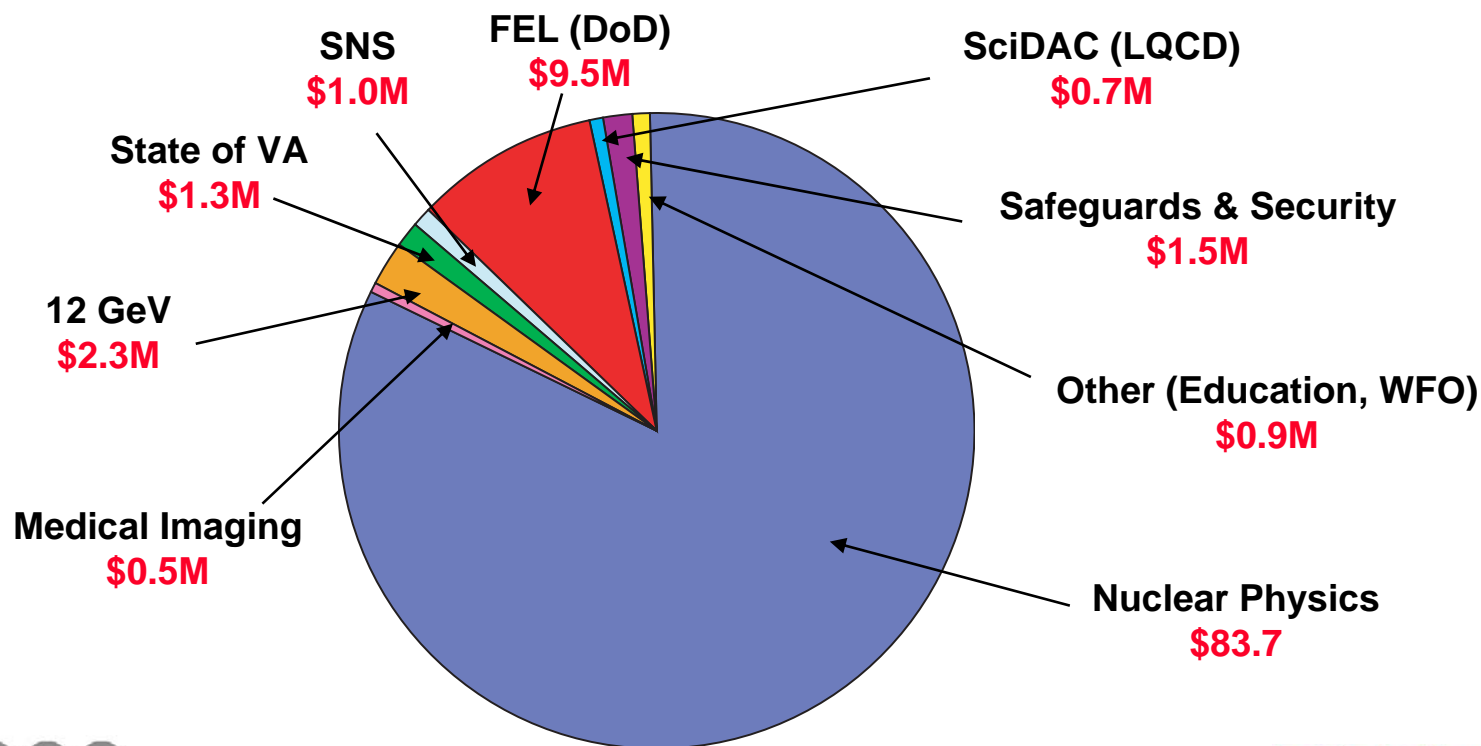
# JLab addressing 8 of 10 SC Milestones in Hadronic Physics

Year	Milestones:
2008	Make measurements of spin carried by the glue in the proton with polarized proton-proton collisions at center of mass energy, $\sqrt{s_{NN}} = 200$ GeV.
2008	Extract accurate information on generalized parton distributions for parton momentum fractions, $x$ , of 0.1 - 0.4 , and squared momentum change, $-t$ , less than 0.5 GeV <sup>2</sup> in measurements of deeply virtual Compton scattering.
2009	Complete the combined analysis of available data on single $\pi$ , $\eta$ , and K photo-production of nucleon resonances and incorporate the analysis of two-pion final states into the coupled-channel analysis of resonances.
2010	Determine the four electromagnetic form factors of the nucleons to a momentum-transfer squared, $Q^2$ , of 3.5 GeV <sup>2</sup> and separate the electroweak form factors into contributions from the u, d and s-quarks for $Q^2 < 1$ GeV <sup>2</sup> .
2010	Characterize high-momentum components induced by correlations in the few-body nuclear wave functions via (e,e'N) and (e,e'NN) knock-out processes in nuclei and compare free proton and bound proton properties via measurement of polarization transfer in the reaction. ${}^4\text{He}(\vec{e}, e'\vec{p}){}^3\text{H}$
2011	Measure the lowest moments of the unpolarized nucleon structure functions (both longitudinal and transverse) to 4 GeV <sup>2</sup> for the proton, and the neutron, and the deep inelastic scattering polarized structure functions $g_1(x, Q^2)$ and $g_2(x, Q^2)$ for $x=0.2-0.6$ , and $1 < Q^2 < 5$ GeV <sup>2</sup> for both protons and neutrons.
2012	Measure the electromagnetic excitations of low-lying baryon states (<2 GeV) and their transition form factors over the range $Q^2 = 0.1 - 7$ GeV <sup>2</sup> and measure the electro- and photo-production of final states with one and two pseudoscalar mesons.
2013	Measure flavor-identified $q$ and $\bar{q}$ contributions to the spin of the proton via the longitudinal-spin asymmetry of W production.
2014	Perform lattice calculations in full QCD of nucleon form factors, low moments of nucleon structure functions and low moments of generalized parton distributions including flavor and spin dependence.
2014	Carry out ab initio microscopic studies of the structure and dynamics of light nuclei based on two-nucleon and many-nucleon forces and lattice QCD calculations of hadron interaction mechanisms relevant to the origin of the nucleon-nucleon interaction.



# Jefferson Lab Vital Statistics

- Managed for the DOE under a performance contract by the Southeastern Universities Research Association (SURA); “outstanding ratings” FY97-FY04
- 696 employees, with 44% having advanced degrees, including 130 with Ph.D.s
- Program-dedicated laboratory with funding as follows (FY05):



# Lab Vision Sets Programmatic Agenda

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**Laboratory Vision was approved by DOE/SC in 2004**

**Aligned with NSAC Long Range Plan recommendations**

**Continue scientific preeminence in hadronic physics**

- **Deliver outstanding 6 GeV experimental program**
- **Utilize Theory & Advanced Computations to optimize scientific results**
- **Realize the 12 GeV Upgrade for continued international leadership**

**Build on SRF core competency**

- **Center of Excellence for Office of Science (HEP, BES) and Nation**
- **Realize potential of FEL for defense applications and basic science**

**Continue emphasis on outstanding safety and business performance**



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# Recent Accomplishments

## Nuclear Physics

- **World-class physics results from all scientific campaigns have gained worldwide attention**
  - **Hypernuclear, G0, Happex II, Primex,  $Q_w$ , DVCS, GPD's...**
- **12 GeV Upgrade on track for CD-1, September 2005**
- **Chief Scientist on board and guiding scientific agenda**
- **384 node Lattice QCD system performing at over 700 Gflops (sustained)**



# Recent Accomplishments (Cont.d)

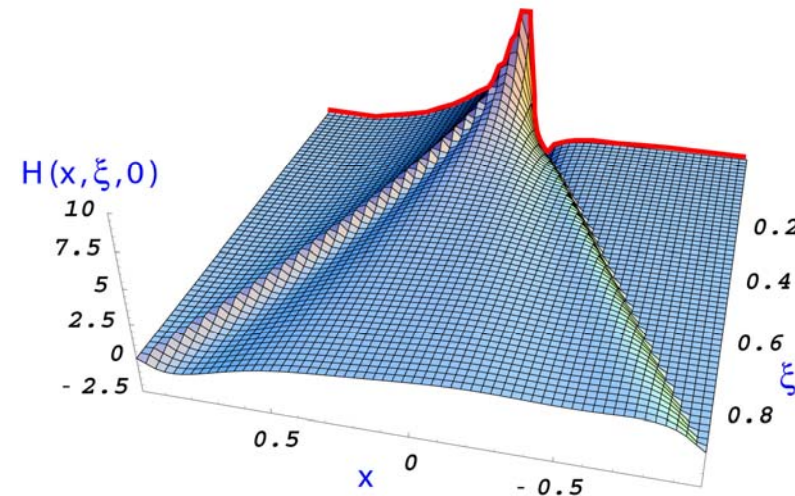
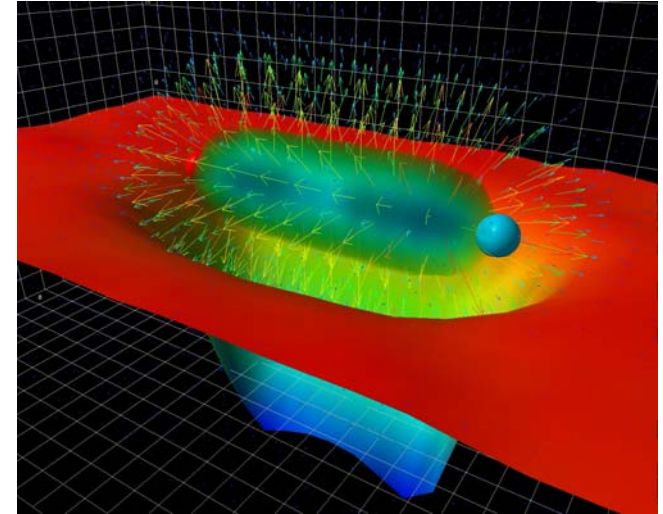
## Science & Technology

- **Delivered SNS cryomodules (exceeding specifications) on-cost and schedule, March 2005**
- **FEL achieved 10 kW, July 2004**
- **FY 2004 resulted in an “Outstanding” rating for the Lab**
- **Safety: Efforts underway to improve lab’s safety record**
  - **No DOE-reportable injuries to date in FY05**
- **CEBAF Center Addition: project well underway; estimated occupancy, January 2006**



# The 12 GeV Upgrade Will Support Breakthrough Programs in Four Areas:

- The experimental study of the confinement of quarks – one of the outstanding questions of the 21<sup>st</sup> century physics
- Dramatic improvements in our knowledge of the fundamental quark-gluon structure of the nuclear building blocks
- Further exploration of the limits of our understanding of nuclei in terms of nucleons and the  $N$ - $N$  force
- Precision experiments with sensitivity to TeV scale physics beyond the Standard Model
- And other science we can't foresee



# 12 GeV Upgrade — Maintain U.S. World Leadership in Hadronic Physics

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- **CD-0 approved by DOE Deputy Secretary McSlarrow, April 2004**
- **Project Director and strong team in place to realize Upgrade**
- **Conceptual Design Report (CDR) in development**
- **Continuing necessary R&D to minimize cost and schedule risk**
- **Exploring potential for foreign collaborators and non-DOE participation**
- **Approval of Critical Decision 1 (CD-1), Sept. 2005**





# Summary

- **Jefferson Lab is strongly aligned with the *Facilities for the Future of Science: A Twenty Year Outlook***

**12 GeV Upgrade will extend scientific reach in a cost-effective manner**

- **This review is an essential step to obtain CD1**

- **Jefferson Lab is uniquely positioned to make outstanding contributions to the Department's science and technology mission**
  - **Advance the frontiers of nuclear physics worldwide for the next three decades**
  - **Provide a national resource for SRF and related technologies, enabling the next generation of research accelerators.**
- **Continued emphasis on corporate citizenship and exemplary management**

